

PHOTOMASK

BACKGROUND OF THE INVENTION

1. Field of the Invention:

The present invention relates to a photomask.

2. Related Art:

In the process for producing semiconductor device, display and others, it is carried out to transfer patterns written on a photomask to a wafer, a substrate of display panel and others. Namely, the steps for transferring patterns of a photomask to a wafer, a substrate of display panel and others are carried out beginning from application of photo resist on a wafer, a base of display panel and others, carrying out demagnification projection by means of stepper, developing the photo resist to form a mask, and etching of liner or under film through photo resist as a mask and a thereafter removing unnecessary areas of the photo resist.

It is said that large-scaled amorphous silicon TFT and LCD for monitor of notebook personal computer and desk top personal computer are produced through five to six of steps of patterning made by photo etching for substrate of TFT. Therefore, it is required that these steps of photolithography are simplified to reduce the cost of production.

However, there is a limit in the simplification of steps of photolithography in a conventional system for transferring patterns to wafer and others by transmitting or shielding projected light through existence or not of shielding patterns on a photomask.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a photomask

which enables the simplification of steps of photolithography.

Inventors made a study in order to attain the above-mentioned object. As a result, inventors found that projecting amounts of rays depending on the area to a wafer becomes possible by a conventional photomask having shielding pattern films made of shielding metallic thin film on a transparent substrate wherein the photomask is further provided with translucent patterns made of translucent metallic thin film mainly including tantalum of materials selected from tantalum silicide, tantalum oxide, tantalum nitride or mixture thereof, that the steps of projection made using the photomask and development bring about a difference in solubility between a part of resist corresponding to shielding patterns and a part of resist corresponding to translucent patterns by which resist pattern comprised of a part of patterns having the thickness of resist patterns formed ordinarily and a part of thinner patterns can be formed and that thereby, it is made possible to make two species of patterning in one photomask so that the reduction of the number of masks are made possible. The inventors made the present invention on the basis of the above-mentioned knowledge.

Namely, the present invention, as mentioned in claim 1, is a photomask provided with shielding patterns made of shielding metallic thin film on a transparent substrate, wherein the photomask further comprises translucent patterns mainly including tantalum of materials selected from tantalum silicide, tantalum oxide, tantalum nitride or mixture thereof.

Layers formed on an insulating substrate, according to the present invention, can be formed into patterns through the steps of overlaying the layers with resist pattern comprised of a part of patterns having the thickness of resist pattern formed ordinarily and

a part of patterns made of thin film, etching the layers through the resist pattern so that the layers are formed into patterns, thereafter removing the part of patterns made of thin film by O₂ ashing and the like so that a part of the layer covered with the part of patterns made of thin film is exposed, and further etching a part of the exposed layer by which the number of steps of photolithography can be reduced.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic sectional view of a photomask of the present invention.

Fig. 2 is a sectional view of resist pattern formed using a photomask of the present invention.

Fig. 3 is a sectional view for illustrating the steps of production of a photomask of the present invention.

Fig. 4 is a sectional view for illustrating the steps of production of a photomask of the present invention made following the steps of production of a photomask shown in Fig. 3.

Fig. 5 is a sectional view showing the steps of patterning made using a photomask of the present invention.

Fig. 6 is a sectional view showing the steps of patterning made using a photomask following the steps of patterning shown in Fig. 5.

PREFERRED EMBODIMENT OF THE INVENTION

Fig. 1 shows conceptually the structure of photomask of the present invention. A photomask of the present invention comprises a transparent substrate 1a and shielding patterns 2 made of shielding metallic thin film wherein the photomask further comprises translucent patterns 3 made of translucent metallic thin film mainly

including tantalum of materials selected from tantalum silicide, tantalum oxide, tantalum nitride or mixture thereof.

In a photomask of the present invention, optically transparent materials such as soda-lime glass, quartz glass, and sapphire can be used as transparent substrate.

Further, materials such as Cr, Cr_2O_3 , and Si can be used as shielding metallic thin film forming shielding patterns.

Intermediate layer such as SiO_2 can be provided between a shielding metallic thin film and a translucent metallic thin film. The intermediate layer prevents translucent metallic thin film from being damaged by over-etching when etching shielding metallic thin film.

In the present invention, the reason that translucent patterns are made of materials mainly including tantalum is based on that materials mainly including tantalum are the most suitable materials that not only make easy the adjustment of optical amounts with the adjustment of thickness, but also have excellent workability and durability.

The translucence of translucent patterns can be adjusted according the thickness of translucent metallic thin film. Further, the adjustment of the translucence of translucent patterns can be possible in the following method: a plurality of openings having size under resolution of limit of aligner are formed in a translucent metallic thin film in such an extent that writing is not made by light passing through the openings so that amounts of applied rays to the whole of translucent pattern is lacking for exposure.

Fig. 2 shows schematically a resist pattern made using a photomask of the present invention. Exposure and development made using a photomask of the present invention produces a difference in solubility of exposed material against developing solution between a

part of resist corresponding to shielding patterns 2 and a part of resist corresponding to translucent patterns 3. Accordingly, a resist pattern comprised of a part 5 of patterns having the thickness of resist pattern formed ordinarily and a part 6 of patterns made of thin film is formed. (In Fig. 2, a photomask is shown with enlarging crosswise a photomask against a photomask shown in Fig. 1 to be easy to be seen.)

Then, referring to Figs. 3 and 4, a method for producing a photomask of the present invention is explained. First, a blank is provided in which translucent metallic thin film 11 mainly including tantalum of materials selected from tantalum silicide, tantalum oxide, tantalum nitride or mixture thereof and shielding metallic thin film 12 made of materials such as Cr and further resist 13 is applied on shielding metallic thin film 12 as shown Fig. 3(a).

Then, a resist pattern 14 for forming shielding patterns is formed carrying out first writing and development as shown in Fig. 3(b).

Then, shielding metallic thin film 12 is etched by wet etching or dry etching so that shielding patterns 2 is formed as shown in Fig. 3 (c).

Then, resist patterns 14 are removed as shown in Fig. 4 (a). Thereafter, resist 13 is again applied on translucent metallic thin film 11 and shielding patterns 2 as shown in Fig. 4(b). Then, second writing and development are carried out so that resist patterns 15 for forming translucent patterns are formed as shown in Fig. 4 (c).

Then, translucent metallic thin film 11 is etched by dry etching or wet etching so that translucent patterns 3 are formed as shown in Fig. 4(d).

Finally, a photomask can be obtained by removing resist as

shown in Fig.1.

Then, referring to Figs. 5 and 6, an example of application of photomask of the present invention is explained.

First, as shown in Fig. 5 (a), gate line 21 is formed on an insulating substrate (not shown) laminating metallic materials such as Al/Mo in the same manner as conventional method, as shown in Fig. 5(a). Then, SiN_x film 22 and a · Si film (amorphous silicon film) 23, N⁺ a · Si film (N⁺ amorphous silicon film)24 are laminated on a insulating substrate provided with gate line 21. Further, film 25 of materials such as a Cr/Mo and Ti/M is laminated on N⁺ a · Si film 24. Thereafter, a resist pattern 26 covering a source electrode, a drain electrode and a channel portion is formed using a photomask of the present invention.

Then, a part of source electrode, drain electrode and pixel electrode and others uncovered by the resist pattern 26 is removed by etching (refer to Fig. 5(b)).

Then, a part of resist thinly formed covering the channel portion is removed by O₂ ashing (refer to Fig. 5(c)).

Then, a part of film 25 of materials such as a Cr/Mo and Ti/M and N⁺ a · Si film (N⁺ amorphous silicon film)24 corresponding to the channel portion is removed by etching and finally, resist is removed (refer to Figs. 6(a)~(c)).

Thereafter, a film of passivation dielectrics is formed so that TFT is obtained.

As mentioned hereinabove, according to the present invention, two species of patterning can be carried out in one mask.

Then, an example of a photomask of the present invention is given.

(Example)

First, a glass polished on double sides with a size of 6 inch × 6 inch and thickness of 0.12 inch is provided. After washing of the glass, tantalum layer with thickness of 200 angstrom and transmittance against rays of wavelength 436 nm more than 20% is formed carrying out sputtering as following conditions.

Sputtering conditions:

(Magnetron sputter)

DC magnetron

A use of metallic tantalum target

Argon gas 50 sccm

Pressure: 0.3 Pa

Current: 3 ampere

Then, a layer of SiO₂ with thickness of 500 angstrom is formed carrying out sputtering under the following conditions.

Sputtering conditions:

(Magnetron sputter)

RF magnetron

A use of SiO₂ target

Argon gas 50 sccm

Pressure: 0.1 Pa

Electric power: 1 kilowatt

Then, double layers of chromium are formed on the layer of SiO₂ carrying out sputtering under the following conditions.

Sputtering Conditions:

(Magnetron sputter)

A use of metallic chromium target

First layer

Argon gas 50 sccm

Pressure: 0.3 Pa

Current: 0.3 ampere

Thickness: 800 angstrom

Second layer

Argon 30 sccm + Oxygen 70 sccm

Pressure: 0.3 Pa

Current: 2 ampere

Thickness: 200 angstrom

Further, resist is applied on the double layers of chromium by a conventional spin coating method, thereafter writing and developing are carried out by an electron beam lithography method to form a resist pattern for forming shielding patterns.

Then, the chromium layer and the SiO_2 layer are etched through the resist pattern under the following conditions to form shielding patterns.

Etching conditions:

A use of dry etching equipment (VLR manufactured by UNAXIS Inc.)

(Etching of chromium)

Etching gas	$\text{Cl}_2 + \text{O}_2$ gas (the ratio of 2:3)
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Pressure	10 mTorr
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ICP power	500 W
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(Power for generating high-density plasma)

Bias power	25 W
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(Power for extracting plasma to the side of substrate)

Time required for etching	360 seconds
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(Etching of SiO_2 layer)

Etching gas	CF_4 gas
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Pressure	100 mTorr
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ICP power	950 W
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(Power for generating high-density plasma)

Bias power 50 W

(Power for extracting plasma to the side of substrate)

Time required for etching 30 seconds

Then, after resist is removed, rinsing was carried out. Thereafter, resist is applied on the formed shielding patterns and alignment writing and development are carried out by a conventional electron beam lithography, so that a resist pattern for forming a translucent patterns is formed. Thereafter, dry etching is carried out under the following conditions to form translucent patterns.

Etching conditions:

A use of dry etching equipment (VLR manufactured by UNAXIS Inc.)

Etching gas Cl_2 gas

Pressure 100 mTorr

ICP power 500 W

(Power for generating high-density plasma)

Bias power 25 W

(Power for extracting plasma to the side of substrate)

Time required for etching 30 seconds

Thereafter, resist was removed and rising is carried out, so that a photomask of the present invention is obtained.

As mentioned hereinabove, a photomask of the present invention is a photomask provided with shielding patterns made of shielding metallic thin film on a transparent substrate, wherein the photomask further comprises translucent patterns mainly including tantalum of materials selected from tantalum silicide, tantalum oxide, tantalum nitride or mixture thereof. Therefore, the photomask of the present invention enables the formation of resist pattern comprised of a part of patterns having the thickness of resist

patterns formed ordinarily and a part of thin patterns. Accordingly, the photomask of the present invention makes possible to make two species of patterning in one mask, so that the steps of photolithography can be reduced. Accordingly, work of patterning made by means of photomask can be carried out with low cost and high throughput.